NOAA Technical Memorandum NMFS-SEFC- 32

NOAA/NMFS FINAL REPORT TO DOE

Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana, 1978-1979

A report to the Department of Energy on work conducted under provisions of Interagency Agreement EL-78-I-0-7146 during 1978-1979.

Volume VIII

INORGANIC

NUTRIENTS

NOVEMBER 1980

NOAA Technical Memorandum NMFS-SEFC- 32

Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana, 1978-1979

VOL. VIII - DETERMINE SEASONAL VARIATIONS IN INORGANIC NUTRIENTS COMPOSITION AND CONCENTRATION IN THE WATER COLUMN

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Volume VIII - INORGANIC NUTRIENTS

TABLE OF CONTENTS

I. EDITORS' SECTION

PROJECT ADMINISTRATION

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LIST OF VOLUMES

This Final Report is printed in nine separate volumes:

Volume I - BENTHOS

Work Unit 2.1 Describe Living and Dead Benthic (Macro-
and Meio-) Communities

Coastal Ecosystems Management, Inc.

R. H. Parker, Ph.D.
A. L. Crowe
L. S. Bohme

Volume II - ZOOPLANKTON

Work Unit 2.2 Determine Seasonal Abundance, Distribution
and Community Composition of Zooplankton

LGL Ecological Research Associates, Inc.

L. A. Reitsema, Ph.D.

Volume III - BACTERIA

Work Unit 2.3 Describe Bacterial Communities

Texas A & M University

J. R. Schwarz, Ph.D.
S. K. Alexander, Ph.D.
S. J. Schropp
V. L. Carpenter

Volume IV - DEMERSAL FISHES AND MACRO-CRUSTACEANS

Work Unit 2.4 Determine Seasonal Abundance, Distribution
and Community Composition of Demersal
Finfishes and Macro-crustaceans

Texas A & M University

A. M. Landry, Ph.D.
H. W. Armstrong, Ph.D.

INTRODUCTION

In compliance with the Energy Policy and Conservation Act of 1975, Title 1, Part B (Public Law 94-163), the Department of Energy (DOE) implemented the Strategic Petroleum Reserve (SPR). The SPR program was implemented in August of 1977 with the goal of storing a minimum of one billion barrels of crude oil by December 22, 1982. After evaluating several physical storage possibilities, DOE determined that storage in commercially developed salt dome cavities through solution-mining processes was the most economically and environmentally advantageous option.

Six areas along the northwestern Gulf of Mexico were to be investigated as potential storage cavern sites. These areas are shown in Figure 1. This project, "Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites Off Louisiana", deals with proposed disposal sites associated with two of the cavern sites, West Hackberry and Weeks Island. The Biological/ Chemical Survey was initiated in April 1978 and was completed in December 1979. Its major products are Final Reports available through the National Technical Information Service (NTIS), Springfield, Virginia; data files available through the Environmental Data and Information Service (EDIS), Washington, D.C., and any research papers that may be written by participating principal investigators and published in scientific or technical journals. Preliminary results were also made available through DOE/NOAA/NMFS project reviews and workshops attended by project participants and various governmental, private and public user groups.

The objectives of the Biological/Chemical Survey were: (1) to describe the biological, physical and chemical components of the marine ecosystem for each disposal site; and (2) to assess, by analysis of Gulf Coast shrimp data, the importance of the Louisiana shrimping grounds in the vicinity of the proposed salt dome brine disposal sites. These objectives were achieved using historical and new data to describe and quantify the biological, chemical, and physical characteristics and the temporal variations of these characteristics in the environments of each proposed disposal site.

The two proposed disposal sites have been extensively examined, using available meteorological, oceanographic, bathymetric and ecological data, in the following two reports:

Environmental Data Service, DOC/NOAA. 1977.

> Analysis of Brine Disposal in the Gulf of Mexico, #2 West
> Hackberry. Report to Federal Energy Administration
> Strategic Petroleum Reserve Program Salt Dome Storage.
> Center for Experiment Design and Data Analysis, NOAA, EDS,
> Marine Assessment Division, Washington, D.C.

Environmental Data Service, DOC/NOAA. 1977.

> Analysis of Brine Disposal in the Gulf of Mexico, #3
> Capline Sector. Report to Federal Energy Administration
> Strategic Petroleum Reserve Program Salt Dome Storage.
> Center for Experiment Design and Data Analysis, NOAA, EDS,
> Marine Assessment Division, Washington, D.C.

The above reports and other pertinent documents are available from the
Department of Commerce, National Technical Information Service, 5285
Port Royal Road, Springfield, Virginia, 22151.

Proposed locations of the West Hackberry (Texoma Sector) and Weeks
Island (Capline Sector) brine disposal sites are shown in Figures 2
and 3, respectively. These sites are subject to change within the
same geographic area pending results of baseline surveys presently
underway.

The proposed West Hackberry disposal site is located approximately 9.7
km (6 miles) south off the coast from Mud Lake at Latitude $29^{\circ}40'$ N
and Longitude $93^{\circ}28'$ W at a bottom depth of about 9 m (30 feet).
Operational requirements and engineering limitations of the proposed
brine diffuser at this site are as follows: length - 933.3 m (3070
feet); orientation -normal to coast; number of ports - 52; length be-
tween ports - 18 m (59 feet); port diameter - 7.6 cm (3 inches);
orientation of port riser - 90° to bottom; and port exit velocity -
7.6 m/sec (25 ft/sec).

The proposed Weeks Island (Capline Sector) disposal site is located
approximately 41.8 km (26 miles) off Marsh Island at Latitude $29^{\circ}04'$N
and Longitude $91^{\circ}45'$ W at a bottom depth of about 9 m (30 feet).
Operational requirements and engineering limitations of the proposed
brine diffuser at this site are as follows: length - 608 m (2000
feet); orientation -normal to coast; number of ports - 34; orientation
to port riser - 90° to bottom, and port exit velocity - 7.6 m/sec (25
ft/sec).

The Biological/Chemical Surveys in the proposed salt dome brine dispo-
sal sites described seasonal abundance, distribution and community

composition of major benthic, planktonic, bacterial and demersal fin-
fish and macro-crustacean ecosystem components; the sediments; the
hydrocarbons and trace metals composition and concentration in the
marine ecosystem; and the seasonal variations in inorganic nutrients
composition and concentration of the water column. The sampling
scheme used for sample collections around the two sites is shown in
Figure 4. A separate data analysis assessed the importance of shrimp-
ing grounds in the vicinity of the proposed brine disposal sites in
terms of historical data on species composition, marketing size cate-
gories and location of commercial shrimp catches within statistical
reporting zones off the Louisiana coast.

Information concerning data from this project is available through the
Program Data Manager: Mr. Jack Foreman, Environmental Data and
Information Service, Page Building No. 2, 3300 Whitehaven Street,
N.W., Washington, D.C.
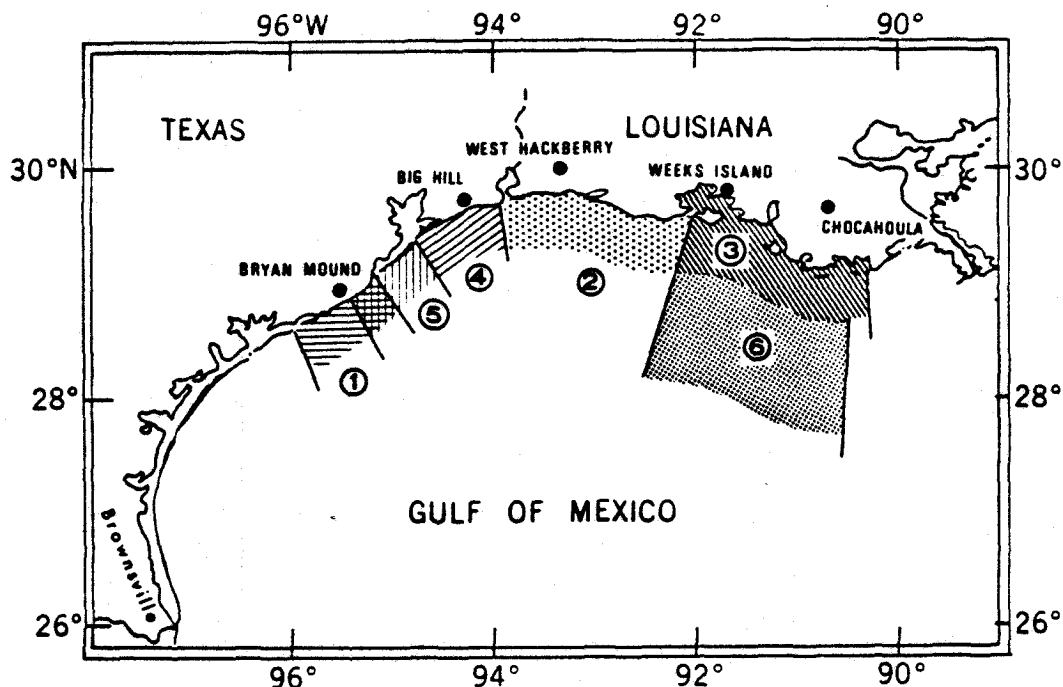
Figure 1. Regions of Study for Brine Disposal Assessment-DOE/NOAA Interagency Agreement (adapted from Environmental Data Service, DOC/NOAA. Analysis of Brine Disposal in the Gulf of Mexico, #2 West Hackberry. 1977.).

1 Texas Coastal Ocean, Colorado River to San Luis Pass (Bryan Mound)

2 Louisiana Coastal Ocean, Sabine Lake to S.W. Pass of Vermilion Bay
   (West Hackberry)

3 Louisiana Coastal Ocean, S.W. Pass, Vermilion Bay to Timbalier Island
   (Capline Sector)

4 Texas Coastal Ocean, Port Bolivar to Sabine Pass

5 Texas Coastal Ocean, Freeport Harbor to Galveston South Jetty

6 Louisiana Coastal Ocean, Offshore from Vermilion Bay to Terrebone Bay
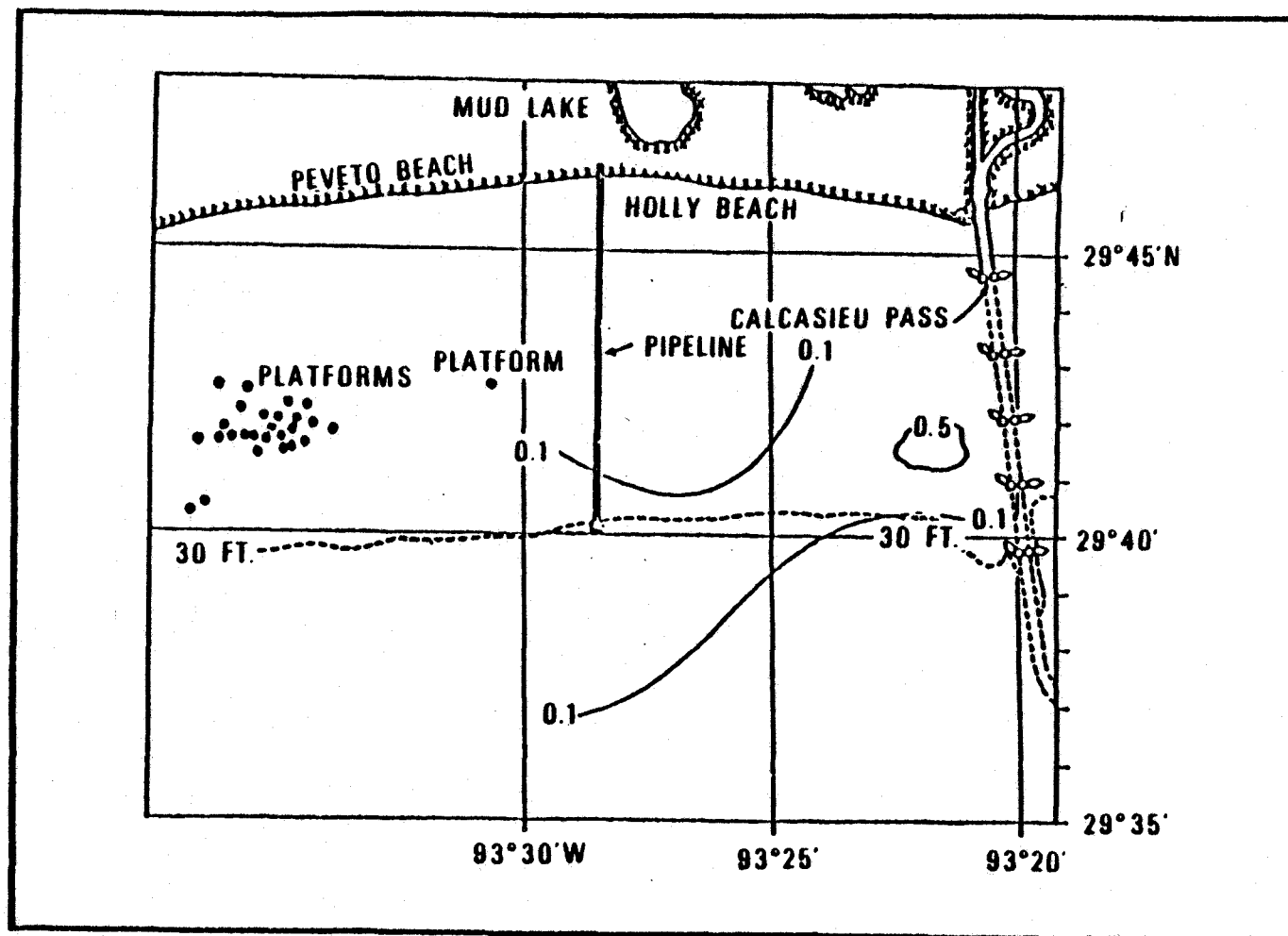
Figure 2. Proposed Texoma brine disposal site.
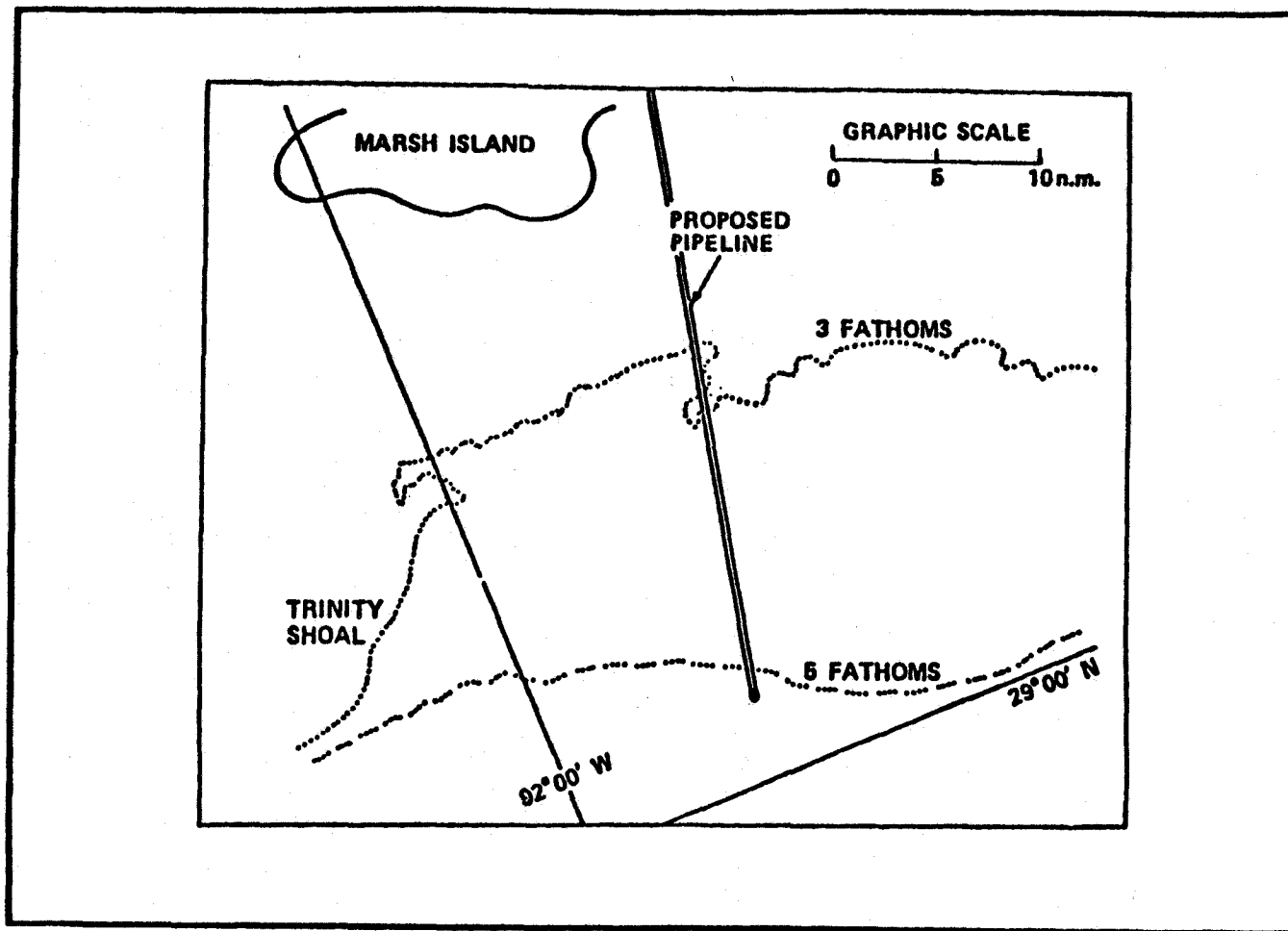
Figure 3.   Proposed Capline brine disposal site.
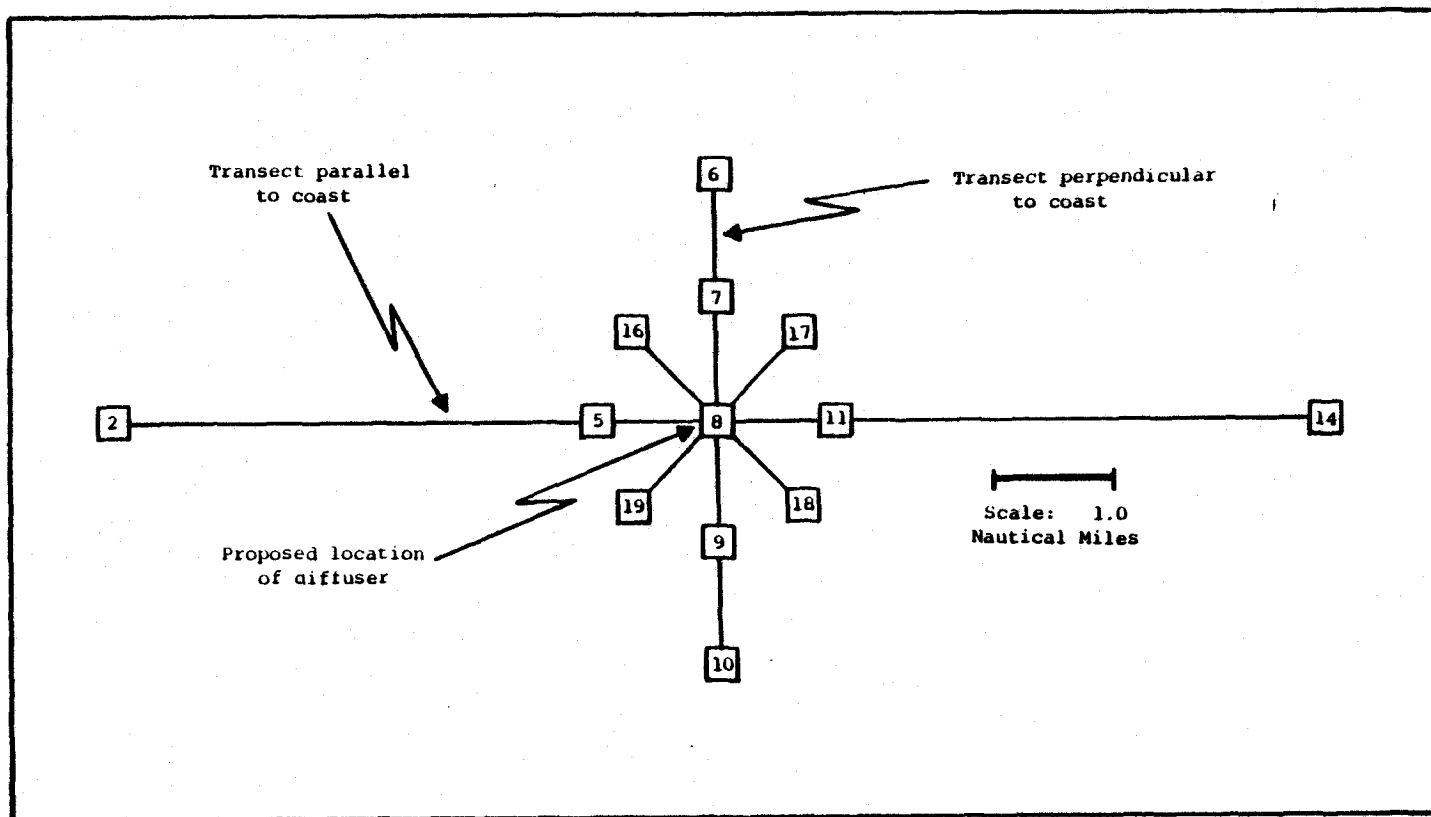
Figure 4.   Sampling scheme for proposed salt dome brine disposal sites.

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and Louisiana. NOAA/NMFS Fishery Bulletin 77(4):985-989.

Caillouet, C. W., D. B. Koi and W. B. Jackson. In press. Relation-
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    1978-1979. NOAA Technical Memorandum NMFS-SEFC-25, 103 p.
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    survey of Texoma and Capline sector salt dome brine disposal sites
    off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-31,
    72 p. Available from: NTIS, Springfield, Virginia.

II.   PRINCIPAL INVESTIGATORS' SECTION

WORK UNIT 3.4 - DETERMINE SEASONAL VARIATIONS IN INORGANIC
NUTRIENTS COMPOSITION AND CONCENTRATIONS IN
THE WATER COLUMN

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ABSTRACT

Seawater samples were analyzed for ammonium nitrogen, nitrate nit-
rogen, nitrite nitrogen, phosphate phosphorus, and dissolved silicate
at the West Hackberry (Texoma) and Weeks Island (Capline) Strategic Pet-
roleum Reserve brine disposal sites. The nutrient concentrations were
typical of the nearshore environment from which the samples were taken.
High ammonia, phosphate, and silicate concentrations were observed in
some near-bottom samples correlating with low oxygen concentrations.
Nitrate showed a negative correlation with salinity suggesting fresh
water inputs as a source of this nutrient.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The results of the Inorganic Nutrient work element (Work Unit 3.4) of the "Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites off Louisiana" are summarized in this report. The goal of this multidisciplinary study was to describe the biological, chemical, and physical components of the marine ecosystem at two proposed disposal sites. The objective of Work Unit 3.4 was to describe the seasonal distribution of inorganic nutrients in the water column. These measurements provide baseline data which can be used to assess the impact of future brine inputs into the system. A secondary objective was to provide ancillary data for the biological components of the study.

The measurement of nutrients is important in studies of possible biological effects of man's activity on marine ecosystems because nutrient concentrations are usually the limiting factor for growth of primary producers. Fluctuations in nutrient levels can, therefore, affect the entire food chain of a marine system. In similar studies, nutrient concentrations have been measured not only for hydrographic information, but as ancillary data for microbiological and phyto-plankton productivity work.

Seawater samples were analyzed at two strategic petroleum reserve proposed brine disposal sites off Louisiana for the following nutrients: (1) ammonium nitrogen, (2) nitrate nitrogen, (3) nitrite nitrogen, (4) phosphate phosphorus, and (5) dissolved silicate. Table 1 and Figures 1 and 2 show station locations sampled at the Weeks Island and West Hack-berry sites. Samples were analyzed from two depths, 1 meter below the sea surface and 1 meter (or less) above the sediment-water interface. The bottom seawater samples were taken as near the sediment-water inter-face as possible, because effects of the high-density brine will most

Table 1. West Hackberry and Weeks Island chemical and biological
stations.

West Hackberry			Weeks Island		
Station	Latitude	Longitude	Station	Latitude	Longitude
A2	29°39'46"	93°33'47"	B2	29°07'58"	91°52'43"
A5	39'54"	29'10"	B5	06'09"	48'37"
A6	41'59"	28'12"	B6	07'31"	46'35"
A7	40'58"	28'08"	B7	06'37"	47'01"
A8	40'00"	28'00"	B8	05'42"	47'36"
A9	38'59"	27'57"	B9	04'49"	48'01"
A10	38'00"	27'52"	B10	03'55"	48'37"
A11	40'04"	26'54"	B11	05'17"	46'32"
A14	40'20"	22'17"	B14	03'26"	42'13"
A16	40'42"	28'48"	B16	06'48"	47'48"
A17	40'42"	27'12"	B17	05'54"	46'24"
A18	39'18"	27'06"	B18	04'48"	47'18"
A19	39'12"	28'42"	B19	05'36"	48'36"

likely be greatest directly above the interface, and the possible exist-
ence of a near-bottom nepheloid layer could affect nutrient levels in this
region.

The distribution of inorganic nutrients in the open Gulf of Mexico is
fairly well known. Williams (1954), El-Sayed et al. (1972), and Corcoran
(1973) have summarized much of the early nutrient work in the Gulf. These
and more recent publications (Berberian and Starr, 1978; Morrison and
Nowlin, 1977; and Carder et al., 1977) have delineated nutrient distribu-
tions in Gulf water masses. One main characteristic of Gulf surface water
is low inorganic nutrient levels. However, knowledge of nutrient levels
in many near-shore areas of the Gulf is incomplete because of rapid fluxes
within these coastal systems. A complete understanding of inorganic nutri-
ent behavior in any coastal system involves a knowledge of the input and
removal rates, the biological particulate carrier phases, modes and rates
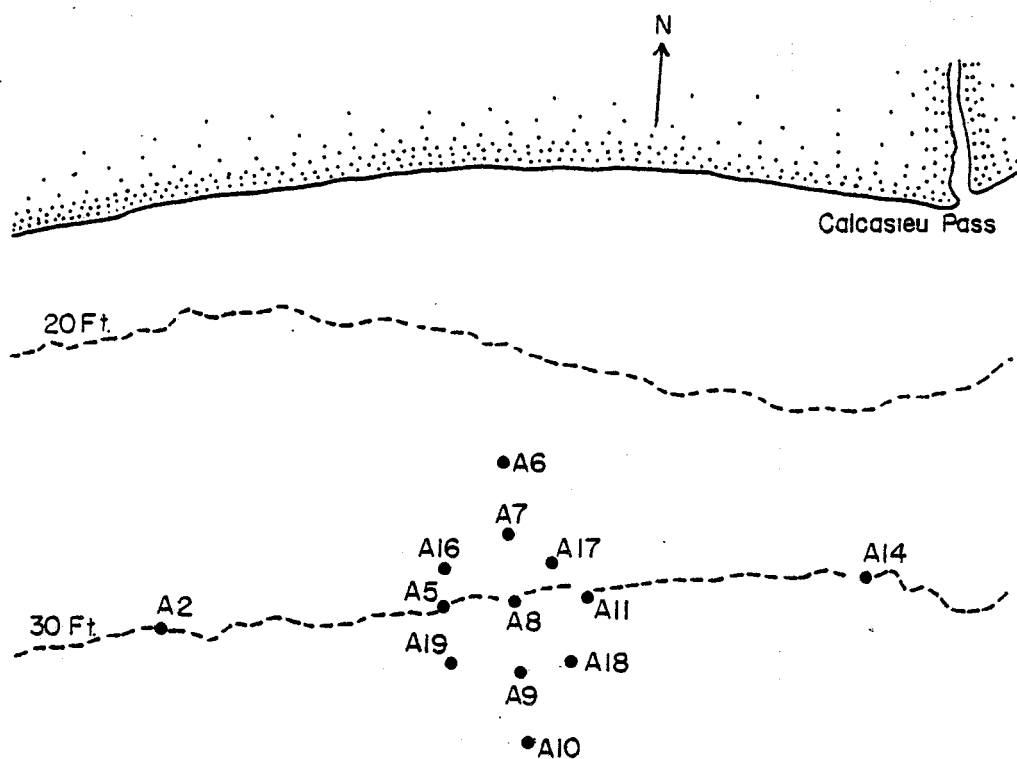
Figure 1. Chemical and biological sampling station locations, West Hackberry.
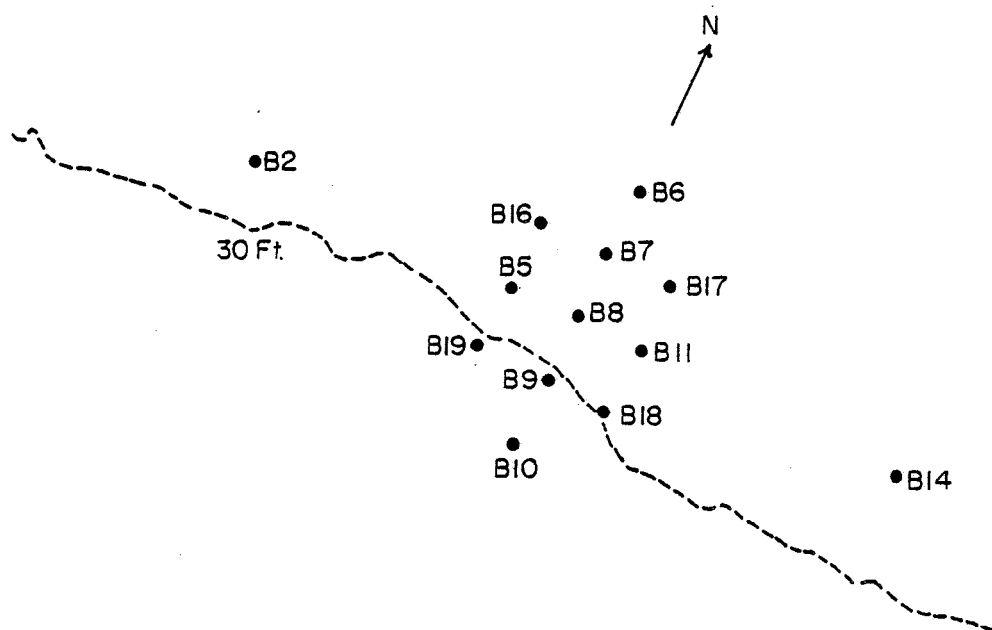
Figure 2. Chemical and biological sampling station locations, Weeks Island.

of recycling within the reservoir, and the effects of physical mixing. This type of information does not exist for most nearshore areas. However, there is a considerable amount of information available on the temporal and spatial distribution of nutrients in coastal areas. Little of this information is in the scientific literature, but is found in various governmental and university technical reports. For example, Table 2 shows monthly mean, minimum, and maximum nitrate, phosphate, and silicate levels in the South Texas Outer Continental Shelf area from the Bureau of Land Management baseline study in this area in 1977 (Sackett and Brooks, 1978). These concentrations represent typical levels for Gulf coastal waters.

<div align="center">METHODS AND MATERIALS</div>

Water samples for nutrient analysis were obtained using two Nansen or Niskin bottles mounted on a hydrowire. The bottom sampler was positioned as close to the hydroweight as feasible for correct operation. Since the water depth is only about 9 meters, positioning of the hydroweight directly at the sediment-water interface was easily accomplished by monitoring the tension on the hydrowire.

Upon retrieval of the bottles, water was immediately drawn into "whirl-pak" sampling bags and frozen for laboratory analysis. Due to the instability of ammonia and nitrite, the absolute concentrations of these components is somewhat questionable, although their relative distributions are useful. Samples were usually analyzed within a few weeks of collection.

Nutrients were analyzed using a TECHNICON AUTOANALYZER II following the methods outlined by Strickland and Parsons (1972),

Table 2. Summary of phosphate, nitrate, and silicate concentrations
in the South Texas OCS area in 1977.

SUMMARY OF NUMBER OF PHOSPHATE OBSERVATIONS, MEAN, MINIMUM AND MAXIMUM CONCENTRATIONS
(µM) OBTAINED SEASONALLY AND MONTHLY IN THE STOCS AREA (1977)

Season	Number of Observations	Mean	Minimum	Maximum	Surface Mean
Winter	71	0.22	0.01	1.88	0.19
March	9	0.25	0.1	0.63	0.20
April	15	0.11	0.05	0.21	0.08
Spring	62	0.21	0.1	4.74	0.11
July	18	0.12	0.1	0.60	0.23
August	20	0.10	0.1	0.42	0.03
Fall	93	0.16	0.03	0.57	0.18
November	20	0.38	0.12	0.94	0.32
December	18	0.40	0.17	0.74	0.30

SUMMARY OF NUMBER OF NITRATE OBSERVATIONS, MEAN, MINIMUM AND MAXIMUM CONCENTRATIONS
(µM) OBTAINED SEASONALLY AND MONTHLY IN THE STOCS AREA (1977).

Season	Number of Observations	Mean	Minimum	Maximum	Surface Mean
Winter	70	1.1	<0.1	7.7	0.8
March	9	0.5	<0.1	3.6	<0.1
April	15	0.8	<0.1	3.5	0.2
Spring	70	0.97	<0.1	4.8	0.3
July	19	1.5	<0.1	13.8	0.2
August	22	1.1	<0.1	9.3	0.1
Fall	93	0.5	<0.1	10.2	0.1
November	20	0.9	<0.1	11.2	0.1
December	18	2.7	0.2	11.8	0.5

SUMMARY OF NUMBER OF SILICATE OBSERVATIONS, MEAN, MINIMUM AND MAXIMUM CONCENTRATIONS
(µM) OBTAINED SEASONALLY AND MONTHLY IN THE STOCS AREA (1977).

Season	Number of Observations	Mean	Minimum	Maximum	Surface Mean
Winter	71	1.7	0.2	5.2	1.7
March	9	1.9	<0.1	4.7	1.6
April	15	2.8	0.8	6.7	3.1
Spring	70	2.0	0.4	7.5	1.2
July	19	2.3	1.3	5.8	2.2
August	21	1.9	0.8	6.3	1.6
Fall	93	4.2	1.4	13.9	5.5
November	20	4.6	2.3	12.7	5.6
December	18	4.3	2.3	7.5	5.0

"A Practical Handbook of Seawater Analysis (Revised)". Specific methods

for each of the nutrients are also given by Technicon Instruments

Corporation of Ardsley, New York, Industrial Methods Bulletins 100-70W,

98-70W, 161-71WB, 105-71WB, and 155-71W. The procedures are outlined

in Appendix I.

RESULTS AND DISCUSSION

The nutrient data from the West Hackberry (Site A) and Weeks Island

(Site B) sites is shown in Appendix II. A summary of the average

inorganic nutrient concentrations during the summer, fall, winter, and

spring samplings is presented in Table 3. Standard deviations of the

13 stations at the sites are presented following the mean in Table 3.

The mean, $\bar{x}$, is calculated by $\sum_{i=1}^{N} x_i$ / N, where x_i = data entry, and N =

number of data entries. Standard deviation is computed using N-1 weighting as

follows: $[\sum_{i=1}^{N} (x_i - \bar{x})^2 / N-1]^{\frac{1}{2}}$. All nutrient concentrations are

μmoles/liter (μM).

Ammonia concentrations were the highest during the summer and spring

sampling. Although ammonia concentrations as high as 44 μM were observed

during the summer sampling, the spring sampling had the highest average

ammonia concentrations with a range from 2.1 to 16.3 μM. During the fall

sampling, concentrations were significantly lower ranging from 0.3 to 6.1

and 0.3 to 3.6 at Sites A and B, respectively. Concentrations were

significantly higher at Site A during the summer, fall, and spring

samplings, but lower during winter sampling of Sites A and B. The summer

sampling showed much greater intrasite variability than the other

sampling seasons.

Nitrate concentrations were generally below 1 μM during the summer

and fall samplings. During the summer, nitrate concentrations at Site A

Table 3. Mean concentrations (μM) of nutrients at sites A and B surface and near-bottom for seasonal samplings.[1]

Parameter	Sampling Season	Site A		Site B	
		Surface	Bottom	Surface	Bottom
Ammonia	Summer	3.8 ± 8.8	15.9 ± 13.1	0.8 ± 1.2	1.8 ± 2.0
	Fall	0.5 ± 0.1	3.4 ± 1.8	0.3 ± 0.1	2.1 ± 0.5
	Winter	4.3 ± 2.0	4.3 ± 2.3	7.8 ± 7.0	5.3 ± 3.2
	Spring	7.1 ± 3.2	6.8 ± 4.2	4.8 ± 2.4	5.0 ± 3.2
Nitrate	Summer	0.1 ± 0.1	0.0 ± 0.1	1.0 ± 0.1	0.1 ± 0.1
	Fall	0.2 ± 0.1	0.3 ± 0.2	0.3 ± 0.2	0.4 ± 0.1
	Winter	2.3 ± 0.85	2.5 ± 0.7	5.1 ± 1.6	2.5 ± 1.5
	Spring	9.30± 2.47	7.52± 1.84	11.0 ± 3.2	10.5 ± 3.3
Nitrite	Summer	0.31± 0.30	0.64± 0.45	0.04± 0.03	0.15± 0.11
	Fall	0.11± 0.04	0.14± 0.06	0.19± 0.06	0.26± 0.09
	Winter	0.32± 0.08	0.37± 0.11	0.36± 0.20	0.93± 0.35
	Spring	0.77± 0.23	0.69± 0.12	0.87± 0.27	0.82± 0.23
Phosphate	Summer	1.29± 0.46	3.96± 1.95	0.61± 0.25	0.88± 0.43
	Fall	0.37± 0.16	0.39± 0.13	0.42± 0.19	0.42± 0.20
	Winter	1.09± 0.51	1.44± 0.89	0.80± 0.12	1.13± 0.58
	Spring	0.41± 0.12	0.49± 0.33	0.36± 0.12	0.43± 0.11
Silicate	Summer	8.4 ± 3.9	40.3 ± 16.0	18.7 ± 5.6	14.2 ± 6.1
	Fall	6.6 ± 3.5	4.9 ± 1.9	3.8 ± 1.5	3.5 ± 1.1
	Winter	12.9 ± 4.3	14.1 ± 3.6	22.2 ± 7.4	9.9 ± 6.6
	Spring	5.0 ± 3.8	2.9 ± 3.4	15.1 ± 5.5	13.6 ± 4.2

[1]Standard deviation of 13 measurements.

were below detection limits (<0.1 µM) at most of the stations. Nitrate concentrations increased dramatically during the spring sampling ranging from 4.4 to 13.1 µM and 3.9 to 14.8 µM at Sites A and B, respectively. Nitrate concentrations were generally higher in surface waters, suggesting that runoff is a significant input of nitrate into these near-shore waters.

During the summer sampling, nitrite concentrations were higher than nitrate concentrations at Site A. During other seasons, nitrite levels averaged less than nitrate. The highest nitrite concentrations were observed during the spring sampling in association with high nitrate levels. Nitrite levels were generally less than 1 µM.

Phosphate concentrations were highest at Site A during the summer and at Site B during the winter. Lower values were observed at both Sites A and B during the fall and spring samplings. Phosphate concentrations were generally higher in near-bottom than surface waters. Site A had higher phosphate levels than Site B.

Silicate concentrations patterned phosphate concentrations in that the summer and winter samplings had considerably higher levels than the other sampling periods. Silicate concentrations ranged between 2.7 to 62.9, 2.5 to 13.3, 3.1 to 32.7, and 0.4 to 20.5 µM for the summer, fall, winter and spring sampling respectively.

Table 4 shows the Pearson product-moment correlation coefficients for nutrients and hydrographic parameters. These coefficients were produced by a standard Statistical Analysis System (SAS) program which computes univariate descriptive statistics. A detailed description of the program is found in Barr et al. (1976). Nitrate showed a negative correlation with salinity, suggesting fresh water inputs from runoff

Table 4. Correlation coefficients for hydrographic parameters.[1]

PARAMETER	AMMONIA[3]	NITRATE[2]	SILICATE[2]	PHOSPHATE[2]
Depth	–	–	–	–
Temperature	–	–	–	–
Salinity	–	-0.61	–	–
Oxygen	–	–	-0.42	-0.42
Ammonia	1.00	–	0.45	0.60
Nitrate	–	1.00	–	–
Silicate	0.45	–	1.00	0.70
Phosphate	0.60	–	0.70	1.00

[1]Only correlations greater than 0.4 or less than -0.4 are
 tabulated. These correlations were considered to be significant.

[2]Based on 255 observations.

[3]Based on 204 observations.

may be a significant source of nitrate nitrogen. Ammonia, silicate and phosphate all showed negative correlations with oxygen, suggesting that the major source of these nutrients is bacterial regeneration from decaying organic detritus which consumes oxygen. Ammonia, silicate and phosphate all show correlations with each other suggesting similar sources.

CONCLUSIONS

The nutrient concentrations are typical of the nearshore environment from which the samples were taken. Some of the ammonia and nitrite values are suspect due to the instability of these two nutrients during the time required for sample transmittal.

The high ammonia, phosphate, and silicate concentrations, particularly in near-bottom samples, correlate with low oxygen concentrations. These nutrients result from oxygen utilizing chemical reactions which decompose the organic detritus within the water column. The source of the low oxygen and high nutrient levels in many of the near-bottom samples is due to a near-bottom nepheloid layer at these sites. Nitrate concentrations were either undetectable or at very low levels in many of the samples containing low oxygen and high ammonia, as would be expected in reducing environments. Nitrate showed a negative correlation with salinity, suggesting fresh water inputs as a source of this nitrient.

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INSTRUMENT METHODS AND PROCEDURES

Silicate

1. Application: The determination of Silica in surface and saline waters.

2. Summary of Method: This automated procedure for determination of soluble silicate silicon is based on the reduction of a silicomolybdate complex in acidic solution to molybdenum blue by ascorbic acid. Oxalic acid is introduced to the sample stream before the addition of ascorbic acid to eliminate phosphates, thereby reducing their interference (Brewer and Riley, 1966).

3. Sample Handling and Preservation: If analysis cannot be performed the day of collection the samples should be preserved by freezing at −20°C.

4. Reagents and Standards:

    4.1 0.1N Sulfuric Acid

    Preparation: Add 2.8 ml sulfuric acid to 800 ml deionized water. Dilute to 1 liter with deionized water.

    4.2 Ammonium molybdate

    Preparation: Dissolve 10 g ammonium molybdate in 1 liter 0.1N sulfuric acid.

    4.3 Oxalic Acid

    Preparation: Dissolve 50 g oxalic acid in 800 ml deionized water and dilute to 1 liter.

    4.4 Ascorbic Acid

    Preparation: Dissolve 18.0 g ascorbic acid in 800 ml of deionized water and dilute to one liter with deionized water. Add 0.5 ml Levor IV (Technicon No. T21-0332) per liter of reagent.

    4.5 Standards:

    4.5.1 Stock Silicate Standard − 100 ppm SiO_2-Si

    Preparation: Dissolve 1.0204 g sodium metasilicate in deionized water and dilute to one liter.

    4.5.2 Standard Solution − 10 ppm SiO_2-Si

Preparation: Dilute 10.0 ml stock standard to 100 ml with deionized water in volumetric flask.

4.5.3 Working Standards - Prepare Daily.
At least 2 levels should be run with analyses to check range and linearity of method. For open ocean samples standards should be diluted with surface seawater. Standard salinity should approximate sample salinity.

5. Procedure:

5.1 Set up cartridge as shown in flow diagram. Sample rate - 30/hr (1:1).

5.2 Pump reagents through cartridge with deionized water in sample line for 5 minutes.

5.3 Set up sampler with standards in decreasing concentrations. Samples are analyzed according to a known sequence.

5.4 Turn on recorder and establish stable reagent baseline at 0 to 1.0 division on chart by adjusting colorimeter apertures. There should be no bubbles in flow cell. Adjust gain setting to appropriate value for range being used.

5.5 Start analyses by turning on sampler. After all samples appear on recorder chart, wash out reagent lines with deionized water for 5 minutes.

6. Calculations:

Compute SiO_2-Si concentrations of samples by comparison of sample peak heights to standard peak height.

7. Detection Limit: 0.2 mg/L

Ortho-Phosphate

1. Application: The automated determination of ortho-phosphate-phosphorus in surface and saline waters.

2. Summary of method: Ammonium molybdate and potassium antimonyl tartrate react with dilute solutions of orthophosphate in an acid medium to form an antimony - phosphomolybdate complex. This complex is reduced by ascorbic acid to an intensely blue colored complex. This color is proportional to the phosphorus concentration (Murphy and Riley, 1962).

3. Sample handling and preservation: If analyses cannot be performed the day of collection, the sample should be preserved by freezing at -20°C.

4. Interferences: 4.1 No interference is caused by copper, iron or silicate at concentrations many times greater than their greatest reported concentration in sea water.

4.2 Silicon at a level of 3.2 ppm Si causes an interference equilivalent to approximately 0.0013 ppm P.

4.3 Arsenate produces a similar color to phosphate and is measured colorimetrically with the phosphate. However, levels of arsenate are so low as to rarely add significantly to the phosphate values.

4.4 The salt error has been found to be less than 1%.

5. Reagents and Standards:

5.1 4.9 N Sulfuric Acid

Preparation: Add 136 ml of conc. sulfuric acid to 800 ml deionized water while cooling the solution. After this solution has cooled, dilute to 1 liter with deionized water.

5.2 Ammonium Molybdate

Preparation: Dissolve 40 g of ammonium molybdate in 800 ml of deionized water. Dilute to one liter.

5.3 Ascorbic Acid

Dissolve 18 g of ascorbic acid in 800 ml of deionized water. Dilute to one liter with deionized water. This reagent must be refrigerated.

5.4 Antimony Potassium Tartrate

Preparation: Dissolve 3.0 g antimony potassium tartrate in 800 ml deionized water. Dilute to 1 liter.

5.5 Combined Working Reagent - Prepare Daily

Preparation: Add 50.0 ml of 4.9N Sulfuric acid, 15 ml ammonim molybdate, 30 ml ascorbic acid, and 5 ml of antimony potassium tartrate. Total volume should be 100 ml. This reagent is only stable for about eight hours.

5.6 Standards

5.6.1 Stock Phosphate Solution - 100 ppm PO_4-P

Preparation: Dissolve 0.4393 g pre-dried KH_2PO_4 in deionized water and dilute to 1 liter.

5.6.2 Standard Solution. Dilute 10.0 ml stock solution in 100 ml of deionized water in a volumetric flask.

5.6.3 Working Standards - Prepare Daily. At least two levels should be run with analyses to check range and linearity of method. For open ocean samples, standards should be diluted with surface sea water.

6. Procedure:

6.1 Set up cartridge as shown in flow diagram. Sample rate - 30/hr (1:1).

6.2 Pump reagents with deionized water in sample line for 5 minutes.

6.3 Set up sampler with standards first in decreasing concentrations. Samples are analyzed in some known sequence.

6.4 Turn on recorder and establish stable reagent baseline at 0 to 1.0 division on chart by adjusting colorimeter apertures. There should be no bubbles in flow cell. Set gain setting at appropriate value for range being used.

6.5 Start analysis by turning on sampler. After all samples have appeared on recorder chart, turn off recorder and wash out reagent lines with deionized water for 5 minutes.

7. Calculations: Compute PO_4-P concentrations of samples by comparison of sample peak heights to standard peak height.

8. Detection Limit: 0.08 µM.

Ammonia

1. Application: The automated determination of ammonia-nitrogen in surface and saline waters.

2. Summary of Method: The intensity of the indophenol blue color, formed by the reaction of ammonia with alkaline phenol hypochlorite, is measured. Sodium nitroprusside is used to intensify the blue complex. A solution of potassium sodium tartrate and sodium citrate is added to the sample stream to eliminate the precipitation of the hydroxides of calcium and magnesium (Bolleter et al., 1961; Tetlow and Wilson, 1964; and Solorzano, 1969).

3. Sample Handling and Preservation: If analyses cannot be performed the day samples are collected, the sample should be perserved by freezing at -20°C.

4. Interference: 4.1 In seawater, calcium and magnesium ions are present in concentrations sufficient to cause pre-

cipitation problems during analyses. The complex-
ing reagent eleminates this problem.

4.2 Any marked variation in acidity or alkalinity
in samples should be avoided, since the intensity
of the color produced in the reaction is pH depend-
ent.

5. Reagents and Standards:

5.1 Complexing reagent - Prepared daily.

Preparation: Dissolve 8.2 g potassium sodium tart-
rate and 6.0 g sodium citrate in 250 ml deionized
water. Adjust the pH of this solution to 6.0 with
conc. sulfuric acid. Use a pH meter for determin-
ation of pH since pH is critical in this method. Add
0.5 ml Brij 35 (Technicon No. T21-0110) per liter before
use.

5.2 Alkaline phenol - Prepare daily.

Preparation: Add 9.4 ml liquid phenol and 18.0 ml
sodium hydroxide to 50 ml deionized water. Dilute
to 100 ml with deionized water.

5.3 Sodium Hypochlorite - Prepare daily.

Preparation: Dilute 20 ml sodium hypochlorite to
100 ml with deionized water.

5.4 Sodium nitroprusside - Prepare daily.

Preparation: Dissolve 0.05 g sodium nitroprusside
in 100 ml deionized water.

5.5 Standards

5.5.1 Stock Ammonia solution - 100 ppm NH_3-N

Preparation: Dissolve 0.4716 g ammonium sulfate in
deionized water and dilute to 1 liter.

5.5.2 Standard Solution - 10 ppm NH_3-N

Preparation: Dilute 10 ml stock solution to 100
ml in a volumetric flask with deionized water.

5.5.3 Working standards - Prepare daily. At least
two levels should be run with analyses to check
range and linearity of method. Standards should be
diluted with both deionized water and seawater to
check pH and efficiency of complexing reagent. For
any given level, standards diluted in deionized water

and seawater should be complete.

6. Procedure: 6.1 Set up manifold as shown in flow diagram.
Do not use heating block. Sample rate 30/hr (1:1).

6.2 Pump reagents with deionized water in sample
line for 5 minutes. Air line is connected to bottle
containing 10% H_2SO_4 to scrub ammonia from air bubbles
being used to segment reagent stream.

6.3 Set up samples with standards first in decreasing
concentrations. Samples are analyzed according to
a known sequence.

6.4 Turn on recorder and establish stable reagent
baseline at 0 to 1.0 division on chart by adjusting
colorimeter apertures. There should be no bubbles
in flow cell. Set gain setting to appropriate
value for range being used.

6.5 Start analyses by turning on sampler. After
all samples appear on recorder, turn off recorder.
Wash out reagent lines with water for 5 minutes.

7. Calculations: Compute NH_3-N concentrations of samples by comparison
of sample peak heights to standard peak height.

8. Detection Limit: 0.2 mg/L

Nitrite

1. Application: The determination of nitrite in surface and saline water.

2. Summary of Method: This automated procedure for the determination of
nitrite is an adaptation of the diazotization method
of Standard Methods (EPA, 1971a). Under acidic
conditions, nitrite ion reacts with sulfanilamide
to yield a diazo compound which couples with N-1-
napthylethylenediamine dihydrochloride to form a
dye which is measured colorimetrically (Kamphake
et al., 1967; Environmental Protection Agency, 1971b)

3. Sample Handling and Preservation: If analyses cannot be performed the
day samples are collected, the samples should be
preserved by freezing at -20°C.

4. Interferences: 4.1 Since the nitrogen species (nitrite, nitrate,
ammonia, amines and other organic nitrogen compounds)
are unstable in natural water, the analyses should
be performed as soon as possible.

4.2 Recent addition of strong oxidants or reductants
to the samples will readily affect the nitrite con-
centrations. High alkalinity will give low results
due to a shift in pH of the color reaction.

5. Reagents and Standards:

6.1 Color reagent.

Preparation: To approximately 350 ml of deionized water, add 50 ml concentrated phosphoric acid and 5.0 g of sulfanilamide. Dissolve completely (heating slightly). Add 0.25 g of N-1-Naphthylethylenediamine dihydrochloride and dissolve. Dilute to 500 ml with deionized water. Filter solution through a 0.4 micron Nuclepore filter. Store in dark bottle in refrigerator (4°C). Before use, add approximately 5 drops Brij-35. Any trace of a pink color indicates this solution is contaminated and should be discarded.

6.2 Standards

6.2.1 Stock nitrite solution - 100 ppm NO_2-N.

Preparation: Dissolve 0.493 g of sodium nitrite in deionized water and dilute to one liter. Store with a few drops of chloroform as a perservative.

6.2.2 Standard nitrite solution.

Preparation: Dilute 1.0 ml stock nitrite solution to 100 ml with deionized water in volumetric flask. Solution equals 1 ppm NO_2-N.

6.2.3 Working standards - Prepared daily. At least 2 levels should be run with analyses to check range and linearity of methods. For open ocean samples, standards may be diluted with surface seawater. However, for the nitrite method there is no appreciable salt effect.

6. Procedure:

6.1 Set up cartridge as shown in flow diagram. Sample rate - 30/hr (1:1).

6.2 Pump reagents with deionized water in sample line for 5 minutes.

6.3 First, set-up sampler with standards in decreasing concentrations. Samples are analyzed in some known sequence.

6.4 Turn on recorder and establish stable reagent baseline at 0 to 1.0 division on chart by adjusting colorimeter aperatures. There should be no bubbles in flow cell. Set gain setting to appropriate value for range being used.

6.5 Start analyses by turning on sampler. After all samples appear on recorder chart, turn off recorder. Wash out reagent lines.

6.6 Blanks must be run on all samples. Run samples with reagent line in deionized water.

7. Calculations: Compute NO_2-N concentrations of samples by comparison of sample peak heights to standard peak heights.

8. Detection Limit: 0.04 μM.

Nitrate

1. Application: The determination of nitrate plus nitrite in surface and saline waters.

2. Summary of Method: This automated procedure for the determination of nitrate plus nitrite utilizes the reduction of nitrate to nitrite by a copper-cadmium reductor column. The nitrites (those initially present plus reduced nitrates) are then combined with sulfanilamide to form a diazo compound which is in turn coupled in an acid solution (pH 2.0-2.5) with N-1-naphthylethylenediamine dihydrochloride to form a reddish-purple azo dye. The azo dye intensity is proportional to the nitrate plus nitrite concentration. Nitrite concentrations must be subtracted from nitrate-nitrite concentrations to obtain nitrate concentrations (Armstrong et al., 1967; EPA, 1971b).

3. Sample Handling and Preservation: If analyses cannot be performed the day samples are collected, the samples should be perserved by freezing at -20°C.

4. Interferences: 4.1 Since the nitrogen species are unstable in natural waters, the analyses should be performed as soon as possible.

4.2 In surface waters normally encountered in surveillance studies, the concentrations of oxidizing or reducing agents and potentially interferring metal ions are well below the limits causing interferences. When present in sufficient concentrations, metal ions may produce a positive error.

5. Reagents and Standards:

5.1 Ammonium Chloride Reagent.

Preparation: Dissolve 10 g of ammonium chloride in alkaline water and dilute to one liter.

5.2 Color Reagent

Preparation: To approximately 350 ml of deionized water, add 50 ml conc. phosphoric acid and 5.0 g of sulfanilamide. Dissolve completely (heating slightly). Add 0.25 g of N-1-Naphthylethylenediamine dihydrochloride and dissolve. Dilute to 500 ml. Filter solution thru 0.4 micron Nuclpore filter. Store in dark at 4°C. Before use, add 5 drops of Brij-35. If any trace of a pink color develops, discard solution.

5.3 Cadmium Powder

Preparation: Using a vegetable grater or a coarse file, file cadmium metal sticks to a coarse powder. Rinse the filings once or twice with a small amount of clean diethyl ether or 1 N HCL followed by a rinse with deionized water to remove grease and dirt. Allow the metal powder to air dry, and store in a well stoppered bottle.

5.3.1 Preparation of Reductor Column:

The reductor column is a U-shaped 14" length of 2.0 mm I.D. glass tubing. About 8 g of previously cleaned cadmium is added to the column. The column is washed with one liter of 2% W/V copper sulfate, followed by a distilled water wash. A minimum of ten washings is usually required. The column should be connected to the manifold only when reagents are in all lines. Great care should be taken to keep air out of the column. When not in use, the column should be stored in ammonium chloride solution with a short piece of tubing connecting both ends of the column.

5.4 Standards

5.4.1 Stock Nitrate Solution - 100 ppm-NO_3-N

Preparation: Dissolve 0.72 g of potassium nitrate in one liter of deionized water. Store with a few drops of chloroform as a perservative.

6. Procedures:

6.1 Set up cartridge as shown in flow diagram without column connected. Sample rate - 30/hr (1:1)

6.2 Pump reagents thru cartridge with deionized water in sample line for 5 minutes.

6.3 Connect column to system.

6.4 Set up sampler with standard in decreasing concentrations. Use both NO_3 and NO_2 standard to check efficiency of reductor column. Samples are analyzed in a known sequence.

6.5 Turn on recorder and establish a stable reagent baseline. There should be no bubbles in flow cell. Start analysis by turning on sampler.

7. Calculation: Computer nitrate plus nitrite - N by comparison of sample peak heights to standard peak heights. To obtain nitrate concentration subtract nitrite from nitrate + nitrite concentration.

8. Detection Limit: 0.04 mg N/L

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APPENDIX II

NUTRIENT DATA FROM THE WEST HACKBERRY (SITE A) AND
WEEKS ISLAND (SITE B) SAMPLING STATIONS

This appendix contains all the nutrient data collected and analyzed during the four surveys conducted during this study. All concentrations are expressed as µM which is equivalent to µg-at/L.

TABLE 1. Concentrations of nutrients during the summer sampling of Texoma and Capline sector salt dome disposal sites.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
A-02	Surface	32.7	0.1	0.36	1.74	7.1
			<0.1	0.36	1.63	7.1
	Bottom	38.0	<0.1	0.81	4.15	40.4
			<0.1	0.83	4.43	40.7
A-05	Surface	0.8	0.1	0.51	2.09	14.9
			0.1	0.51	2.02	14.8
	Bottom	14.6	0.5	1.68	3.94	45.7
			0.4	1.70	4.13	46.0
A-06	Surface	0.7	0.1	0.42	1.38	11.5
			0.1	0.43	1.38	11.5
	Bottom	0.8	<0.1	0.62	1.96	20.5
			0.1	0.63	2.02	20.5
A-07	Surface	0.5	<0.1	0.25	1.54	9.5
			0.1	0.26	1.54	9.5
	Bottom	6.9	<0.1	0.36	1.91	13.8
			<0.1	0.37	1.96	13.9
A-08	Surface	0.3	<0.1	0.4	0.88	11.3
			<0.1	0.4	0.88	11.3
	Bottom	3.9	<0.1	0.46	3.00	33.0
			<0.1	0.45	3.13	33.1
A-09	Surface	1.0	<0.1	0.05	1.25	5.8
			<0.1	0.04	1.20	5.8
	Bottom	4.9	0.1	0.49	4.56	49.5
			<0.1	0.47	4.65	49.5
A-10	Surface	0.3	<0.1	0.02	0.74	4.8
			<0.1	0.02	—	4.8
	Bottom	5.9	<0.1	1.19	2.54	43.0
			<0.1	1.19	2.86	42.9
A-11	Surface	2.1	<0.1	0.06	1.62	5.3
			<0.1	0.07	1.57	5.2
	Bottom	44.0	<0.1	0.10	8.08	62.9
			<0.1	0.10	8.08	62.9
A-14	Surface	1.6	0.2	1.12	0.68	2.9
			0.2	1.12	0.69	2.7
	Bottom	12.2	<0.1	0.66	2.07	27.4
			<0.1	0.66	2.02	27.5

TABLE 1. Cont'd.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
A-16	Surface	4.1	0.3	0.33	1.40	15.2
			0.3	0.43	1.41	15.2
	Bottom	16.3	<0.1	0.30	6.96	71.0
			<0.1	0.30	7.00	71.0
A-17	Surface	0.5	<0.1	0.40	1.86	8.7
			<0.1	0.39	1.83	8.7
	Bottom	16.9	<0.1	0.40	2.27	28.9
			<0.1	0.41	2.55	29.0
A-18	Surface	0.5	<0.1	0.05	0.67	4.7
			<0.1	0.04	0.68	4.6
	Bottom	25.9	<0.1	0.22	5.49	46.6
			<0.1	0.22	—	46.6
A-19	Surface	3.9	<0.1	0.06	1.09	8.5
			<0.1	0.06	1.08	8.5
	Bottom	17.6	<0.1	1.10	3.79	41.1
			<0.1	1.11	3.88	41.2
B-02	Surface	4.6	0.2	0.03	0.60	19.0
			0.2	0.03	0.52	19.1
	Bottom	6.2	0.1	0.30	1.32	26.3
			0.1	0.30	1.34	26.4
B-05	Surface	0.7	0.9	0.05	0.30	20.1
			1.3	0.05	0.31	20.1
	Bottom	0.8	0.1	0.24	1.24	19.2
			0.1	0.24	1.23	19.1
B-06	Surface	0.5	2.5	0.11	0.57	29.9
			2.4	0.11	0.47	29.9
	Bottom	0.6	0.3	0.14	0.90	16.9
			0.3	0.14	0.90	17.0
B-07	Surface	0.3	1.8	0.06	0.39	21.6
			1.9	0.06	0.24	21.6
	Bottom	0.6	0.2	0.10	0.25	13.8
			0.2	0.11	0.26	13.8
B-08	Surface	0.3	0.1	<0.01	1.40	18.7
			<0.1	<0.01	1.15	18.8
	Bottom	0.5	<0.1	0.03	0.59	6.2
			<0.1	0.02	0.62	6.2

TABLE 1. Cont.

Sample Designation	Depth	Anunonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
B-09	Surface	0.4	1.0	<0.01	0.72	16.3
			1.0	<0.01	0.71	16.4
	Bottom	0.9	0.2	0.29	1.75	16.6
			0.2	0.29	1.85	16.7
B-10	Surface	1.0	<0.1	0.04	0.64	17.6
			<0.1	0.04	0.65	17.6
	Bottom	5.6	0.1	0.31	1.06	17.3
			0.2	0.31	1.12	17.4
B-11	Surface	0.2	1.3	0.06	0.49	21.5
			1.4	0.06	0.45	21.6
	Bottom	0.5	0.1	0.15	0.72	15.1
			0.1	0.16	0.75	15.1
B-14	Surface	0.4	0.1	0.05	0.76	8.3
			0.1	0.05	0.63	8.3
	Bottom	1.4	<0.1	<0.01	0.81	3.0
			<0.1	<0.01	0.85	2.9
B-16	Surface	0.8	2.0	0.06	0.38	23.0
			2.0	0.06	0.38	22.8
	Bottom	1.2	<0.1	0.15	0.34	17.5
			<0.1	0.16	0.37	17.6
B-17	Surface	0.9	1.6	0.06	0.70	21.9
			1.6	0.06	0.72	22.1
	Bottom	0.5	0.2	0.03	0.42	8.8
			0.1	0.03	0.49	8.9
B-18	Surface	0.5	0.7	0.03	0.66	15.7
			0.8	0.03	0.66	15.7
	Bottom	0.7	<0.1	0.13	1.08	9.0
			<0.1	0.12	1.11	9.0
B-19	Surface	0.2	1.0	0.03	0.68	9.7
			1.0	0.03	0.77	9.4
	Bottom	3.2	0.1	0.18	0.83	14.5
			0.1	0.18	0.86	14.5

TABLE 2. Concentrations of nutrients during the fall sampling of Texoma and
Capline sector salt dome disposal sites.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
A-02	Surface	0.3	0.20	0.12	0.33	4.0
	Bottom	2.6	0.23	0.12	0.50	4.7
A-05	Surface	0.5	0.17	0.09	0.37	5.3
	Bottom	2.3	0.20	0.12	0.67	9.7
A-06	Surface	0.5	0.40	0.09	0.40	4.0
	Bottom	2.3	0.47	0.24	0.53	5.3
A-07	Surface	0.5	0.17	0.09	0.27	6.8
	Bottom	6.4	0.40	0.24	0.53	5.2
A-08	Surface	0.5	0.20	0.12	0.60	9.2
	Bottom	2.3	0.17	0.09	0.30	4.3
A-09	Surface	0.5	0.10	0.09	0.23	4.2
	Bottom	3.6	0.13	0.09	0.20	2.8
A-10	Surface	0.5	0.10	0.06	0.30	5.3
	Bottom	2.1	0.13	0.09	0.40	6.7
A-11	Surface	0.8	0.27	0.09	0.37	4.0
	Bottom	5.6	0.27	0.12	0.30	2.8
A-14	Surface	0.5	0.33	0.21	0.43	13.2
	Bottom	5.1	0.53	0.15	0.37	3.3
A-16	Surface	0.3	0.30	0.15	0.77	13.3
	Bottom	2.3	0.17	0.09	0.37	5.3
A-17	Surface	0.5	0.37	0.15	0.40	8.8
	Bottom	6.1	0.53	0.21	0.40	3.5
A-18	Surface	0.3	0.10	0.09	0.23	4.3
	Bottom	1.5	0.17	0.12	0.23	3.5
A-19	Surface	0.3	0.13	0.09	0.20	3.7
	Bottom	1.5	0.20	0.12	0.33	6.2
B-02	Surface	0.5	0.37	0.18	0.30	3.2
	Bottom	2.0	0.40	0.33	0.37	2.8
B-05	Surface	0.5	0.23	0.18	0.37	3.7
	Bottom	2.0	0.47	0.39	0.57	4.3
B-06	Surface	0.3	0.83	0.30	0.83	7.5
	Bottom	2.3	0.60	0.33	0.77	5.7

TABLE 2. Cont'd.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
B-07	Surface	0.3	0.40	0.27	0.70	5.8
	Bottom	2.3	0.30	0.24	0.33	3.5
B-08	Surface	0.3	0.27	0.24	0.23	2.8
	Bottom	2.3	0.30	0.27	0.23	2.5
B-09	Surface	0.5	0.33	0.24	0.37	3.3
	Bottom	2.0	0.30	0.21	0.30	2.5
B-10	Surface	0.3	0.23	0.12	0.30	2.5
	Bottom	3.6	0.30	0.21	0.27	2.5
B-11	Surface	0.3	0.27	0.15	0.47	3.8
	Bottom	2.0	0.23	0.12	0.27	2.7
B-14	Surface	0.3	0.20	0.09	0.20	2.3
	Bottom	2.0	0.20	0.12	0.20	2.2
B-16	Surface	0.3	0.33	0.18	0.63	5.0
	Bottom	2.0	0.57	0.42	0.67	4.7
B-17	Surface·	0.3	0.33	0.18	0.40	3.5
	Bottom	2.0	0.23	0.18	0.30	2.8
B-18	Surface	0.3	0.27	0.18	0.40	3.2
	Bottom	1.5	0.40	0.30	0.63	4.3
B-19	Surface	0.3	0.27	0.18	0.30	2.5
	Bottom	1.5	0.37	0.27	0.63	4.7

TABLE 3. Concentrations of nutrients during the winter sampling of Texoma and
Capline sector salt dome disposal sites.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
A-02	Surface	5.4	2.00	0.23	0.62	12.9
	Bottom	3.6	2.12	0.34	0.92	16.7
A-05	Surface	8.2	3.27	0.34	0.85	15.4
	Bottom	1.4	3.31	0.34	0.77	16.5
A-06	Surface	5.7	2.04	0.46	1.77	13.7
	Bottom	7.5	2.19	0.57	3.85	15.0
A-07	Surface	5.4	2.23	0.26	1.85	11.5
	Bottom	4.6	3.42	0.40	1.77	17.3
A-08	Surface	2.9	1.38	0.34	1.23	7.9
	Bottom	7.9	1.96	0.26	0.92	10.8
A-09	Surface	7.1	2.23	0.29	0.92	13.3
	Bottom	5.4	2.31	0.29	1.00	13.5
A-10	Surface	1.4	1.58	0.23	0.54	10.0
	Bottom	3.9	1.73	0.37	1.15	12.3
A-11	Surface	1.8	3.19	0.37	1.38	18.1
	Bottom	3.6	3.42	0.57	2.12	18.8
A-14	Surface	2.9	3.23	0.40	1.54	17.7
	Bottom	2.1	3.19	0.40	1.54	17.3
A-16	Surface	4.3	3.96	0.37	1.69	20.4
	Bottom	4.6	3.27	0.46	1.92	17.3
A-17	Surface	4.6	1.96	0.34	1.77	10.6
	Bottom	7.5	2.38	0.34	1.62	11.9
A-18	Surface	2.5	2.12	0.20	0.50	11.0
	Bottom	1.9	1.65	0.26	0.58	8.8
A-19	Surface	3.9	1.00	0.29	0.54	5.2
	Bottom	1.4	1.19	0.23	0.54	7.3
B-02	Surface	6.6	2.57	0.42	0.77.	10.8
	Bottom	5.5	1.96	1.31	0.62	6.5
B-05	Surface	4.9	6.87	0.53	0.85	30.0
	Bottom	3.8	2.15	1.67	0.85	6.3
B-06	Surface	5.5	7.70	0.36	1.00	32.7
	Bottom	5.5	1.85	0.61	1.77	9.8

TABLE 3. Cont'd.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
B-7	Surface	4.9	6.42	0.42	0.77	28.7
	Bottom	4.4	5.66	0.58	1. 77	3.8
B-3	Surface	6.6	4.72	0.61	0.92	20.8
	Bottom	5.5	1.40	1.03	1.31	5.6
B-9	Surface	3.8	5.28-	0.47	0.81	22.9
	Bottom	2.2	0.87	0.61	0.73	3.1
B-10	Surface	4.4	5.70	0.47	0.73	24.4
	Bottom	2.7	1.62	1.19	0.54	5.0
B-11	Surface	29.7	2.26	0.22	0.77	9.8
	Bottom	14.3	3.40	0.89	2.42	16.9
B-14	Surface	8.8	6.94	0.44	0.88	30.4
	Bottom	5.5	5.40	0.56.	1.50	26.3
B-16	Surface	11.5	3.17	1.06	0.96	13.1
	Bottom	6.6	3.09	1.00	0.92	13.1
B-17	Surface	6.0	4.83	0.31	0.69	21.5
	Bottom	7.7	2.49	0.72	0.96	11.3
B-18	Surface	3.8	4.91	0.33	0.58	20.8
	Bottom	2.7	1.06	0.67	0.50	3.8
B-19	Surface	3.3	5.40	0.39	0.69	22.7
	Bottom	2.2	1.62	1.25	0.85	5.4

TABLE 4. Concentrations of nutrients during the spring sampling of Texoma and
Capline sector salt dome disposal sites.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM))	Silicate (uM)
A-02	Surface	6.2	10.38	0.85	0.42	1.6
	Bottom	10.9	4.38	0.51	0.38	0.4
A-05	Surface	7.8	10.38	0.87	0.46	4.2
	Bottom	2.1	7.38	0.75	0.33	0.5
A-06	Surface	10.4	7.75	0.57	0.33	9.1
	Bottom	4.2	10.63	0.75	0.33	11.8
A-07	Surface	9.3	10.25	0.91	0.54	7.8
	Bottom	3.5	10.63	0.89	0.50	6.9
A-08	Surface	2.6	13.13	0.98	0.33	13.8
	Bottom	9.4	7.38	0.64	0.29	1.3
A-09	Surface	7.4	11.00	0.58	0.42	2.2
	Bottom	3.0	7.75	0.70	0.25	0.4
A-10	Surface	2.7	8.50	0.77	0.33	0.4
	Bottom	11.5	5.75	0.58	1.50	0.7
A-11	Surface	5.4	11.63	1.00	0.54	5.1
	Bottom	5.1	6.63	0.66	0.54	1.8
A-14	Surface	10.2	8.13	0.68	0.42	4.2
	Bottom	16.3	6.00	0.57	0.67	1.3
A-16	Surface	5.3	5.75	0.49	0.33	3.1
	Bottom	5.9	8.50	0.77	0.50	4.7
A-17	Surface	7.7	11.88	1.23	0.67	3.8
	Bottom	5.1	8.50	0.85	0.42	2.9
A-18	Surface	13.6	5.00	0.40	0.25	8.4
	Bottom	8.6	8.38	0.77	0.38	4.0
A-19	Surface	4.2	7.13	0.70	0.29	0.9
	Bottom	3.4	5.88	0.57	0.25	0.5
B-02	Surface	3.5	11.63	0.85	0.46	12.4
	Bottom	2.7	11.75	0.91	0.38	14.2
B-05	Surface	10.6	14.75	1.19	0.58	20.5
	Bottom	5.3	14.38	1.00	0.42	17.8

TABLE 4. Cont'd.

Sample Designation	Depth	Ammonia (uM)	Nitrate (uM)	Nitrite (uM)	Phosphate (uM)	Silicate (uM)
B-06	Surface	5.4	7.25	0.49	0.21	8.2
	Bottom	2.4	6.81	0.47	0.38	7.6
B-07	Surface	2.9	13.38	1.04	0.50	19.5
	Bottom	13.9	8.63	0.68	0.67	11.3
B-08	Surface	3.2	13.25	0.94	0.33	16.7
	Bottom	3.8	13.50	0.98	0.42	17.1
B-09	Surface	5.6	13.75	1.06	0.25	18.5
	Bottom	3.2	13.13	1.04	0.42	16.7
B-10	Surface	5.0	8.00	0.64	0.29	9.5
	Bottom	6.9	11.75	0.96	0.46	14.5
B-11	Surface	3.0	14.00	1.28	0.42	23.3
	Bottom	5.1	13.75	1.00	0.46	18.5
B-14	Surface	7.2	11.88	0.96	0.46	19.6
	Bottom	2.4	3.94	0.38	0.21	6.2
B-16	Surface	3.2	6.13	0.53	0.25	8.2
	Bottom	6.7	6.88	0.60	0.58	8.7
B-17	Surface	5.8	6.31	0.53	0.25	8.4
	Bottom	4.0	11.50	0.94	0.38	16.4
B-18	Surface	2.4	12.00	0.94	0.38	16.5
	Bottom	3.4	10.13	0.83	0.38	13.8